

Bureau of Mines
Report of Investigations 4627



INVESTIGATION OF THE ATOLIA TUNGSTEN MINES
SAN BERNARDINO COUNTY, CALIF.

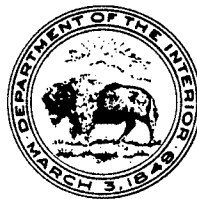
BY FRANK J. WIEBELT AND SPANGLER RICKER

United States Department of the Interior — February 1950

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UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary
BUREAU OF MINES
James Boyd, Director

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by

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INTRODUCTION AND SUMMARY

In its efforts to maintain production of tungsten during the recent war period, the Bureau of Mines explored certain parts of the properties of the Atolia Mining Co. in San Bernardino County, Calif., by diamond drilling. Owing to past production record and other available data, the area was considered attractive for possible development of new ore bodies.

Scheelite occurs in narrow veins ranging in width from a fraction of an inch to several feet. The veins are in quartz monzonite in a zone 2 miles long and 500 feet wide. Production from the district was reported to have been over 1,000,000 units of WO_3 .

Twelve diamond-drill holes, totaling 5,056 feet, were drilled by the Bureau of Mines in the vicinity of the Papoose, Papoose No. 5, Amity, and Union mines, the tailings pond, and the "Old Spud Patch." The work began in August 1943 and was completed in June 1944.

This publication briefly describes the history and deposits of the district and gives full details of the work performed by the Bureau.

ACKNOWLEDGMENTS

The Bureau is indebted to C. W. Chesterman, of the U. S. Geological Survey, for his aid in planning the work, mapping the geology, and logging the diamond-drill cores. W. L. Cox, resident engineer for the Atolia Mining Co. at the time of the project, also was of great help to the Bureau of Mines.

A. C. Rice, of the Metallurgical Division, supervised the analytical work.

HISTORY

Mineral production was first recorded from the Atolia district in 1893 from small dry placer operations for gold. Scheelite was first identified in 1904 at the St. Elmo gold mine, south of Atolia, but it was not until 1906 that the district became known as a tungsten producer. Since that date it has been a consistent producer, reaching the peak production of more than 116,000 units of WO_3 in 1917.

The Atolia Mining Co., which was organized in 1905, accounts for around 90 percent of the total production of about 1,000,000 units of WO_3 . Lemmon and Dorr^{2/} estimate that the production from placers up to 1940 was roughly

^{2/} Lemmon, D. M., and Dorr, John V. N., II, Tungsten Deposits of the Atolia District, San Bernardino and Kern Counties, Calif.: Geol. Survey Bull. 922 (h), 1940, pp. 205-245.

6 percent of the total. From 1943 through 1946, 55,400 units of the total production of 70,300 units was derived from the Hoefling Brothers placer operations. At present the district is inactive.

OWNERSHIP

Nearly all of the principal lode-mining claims in the Atolia district are owned by the Atolia Mining Co., 1022 Crocker Building, San Francisco, Calif. The company's mineral acreage comprises 58 claims and fractions totaling approximately 980 acres. All but several claims held in fee simple are patented.

A group of claims owned by P. J. Osdick, of Atolia, adjoins the Atolia Mining Co.'s property on the east. Other holdings in the district are the Raynor group of 10 claims owned by J. C. Raynor of Atolia, which adjoins the Atolia Mining Co. property on the south; the Treasury group, adjoining the Osdick group on the south; the Black Hawk group of 5 claims 1 mile west of Atolia; and the Buckeye group of three claims lying to the north of the Black Hawk group.

For additional historical and geological details as to the district, reference is made to the following publications:

Delbear, S. H., The Occurrence of Tungsten in the Rand District: Eng. and Min. Jour., vol. 90, 1910, pp. 904-905.

Hulin, Carlton, D., Geology and Ore Deposits of the Randsburg Quadrangle of California: California State Mining Bureau Bull. 95, 1925, pp. 70-79, 125-128.

Nevius, J. N., Notes on the Randsburg Tungsten District: Min. and Eng. World, vol. 45, 1916, pp. 7-8.

Vanderburg, Wm. O., Report on an Exploration Project in the Atolia Tungsten District, San Bernardino County, Calif., May 1940.

Lemmon, D. M., and Dorr, John V. N., 2d, Tungsten Deposits of the Atolia District, San Bernardino and Kern Counties, Calif.: Geol. Survey Bull. 922 (h), 1940, pp. 205-245.

PHYSICAL FEATURES

The Atolia tungsten district is in the western part of San Bernardino County, Calif., near its boundary with Kern County. A portion of the tungsten field extends into Kern County. The camp of Atolia, in the central part of the tungsten area, is 43 miles northeast of the town of Mojave and 23 miles north of Kramer, the latter a station on the Atchison, Topeka & Santa Fe Railroad.

The district is accessible by automobile over hard-surfaced roads either from the north via Bishop or from the south via either Kramor or Mojave; it is sometimes considered a part of the Randsburg gold-silver district, which is several miles north and east. The town of Randsburg, in the center of the district of the same name, is 5 miles north of Atolia.

The nearest railroad point is Searles Station, 12 miles north and on the Mojave-Owenyo branch of the Southern Pacific System. The district is served by truck line from Los Angeles, 150 miles distant.

The tungsten area is situated on an undulating plain with a general slope to the south and southeast of about 150 feet to the mile. Drainage is from the Rand Mountains and Red Mountain, an isolated mountain of red andesite, which is a prominent landmark in this locality. A desert wash with little topographical expression runs along the west side of Red Mountain in a south and southeast direction across the series of tungsten veins. This surface-drainage channel empties into Cuddeback Lake, one of the many dry lakes of the Mojave Desert. Except during occasional cloudbursts, the drainage channels carry no water, and there is no subsurface drainage.

The altitude of the tungsten area ranges from 3,100 to 3,600 feet. The topography does not permit mining development by adits; all exploring and prospecting has been done through shafts, either vertical or inclined about 70°.

The climate is semiarid, and mining operations can be carried on throughout the entire year without difficulty. Strong winds are frequent. The principal vegetation is greasewood and sagebrush.

ORE DEPOSITS

The productive zone, along which most of the mines are situated, comprises a narrow belt that crosses the area from east to west. This strip is approximately 2 miles long and 500 feet wide. Generally, the scheelite occurs in narrow veins ranging in width from a fraction of an inch to several feet. In exceptional cases, ore bodies 5 to 17 feet thick have been mined. The veins are found in the Atolia quartz monzonite, probably of Jurassic age, which contains minor intrusions of diorite, aplite, and red granite. Diabase dikes, probably of Miocene age, cut the quartz monzonite in the Union and Star No. 3 mines. Quaternary alluvium covers most of the surface.

The ore is high-grade massive scheelite in a gangue of quartz, calcite, and crushed quartz monzonite. Minor quantities of pyrite and stibnite occur locally in the veins.

Mineralization does not occur in a single continuous vein, but rather along a zone of shearing or fissuring which, in a given section, may comprise several fissures roughly parallel but in some places uniting or branching. The veins strike from N. 75° E. to N. 75° W. and dip between 45° and 90°. Both cross and thrust faults are common throughout the area. Some of these faults are post-mineral and cause offsets in the veins. Scheelite is the only ore mineral.

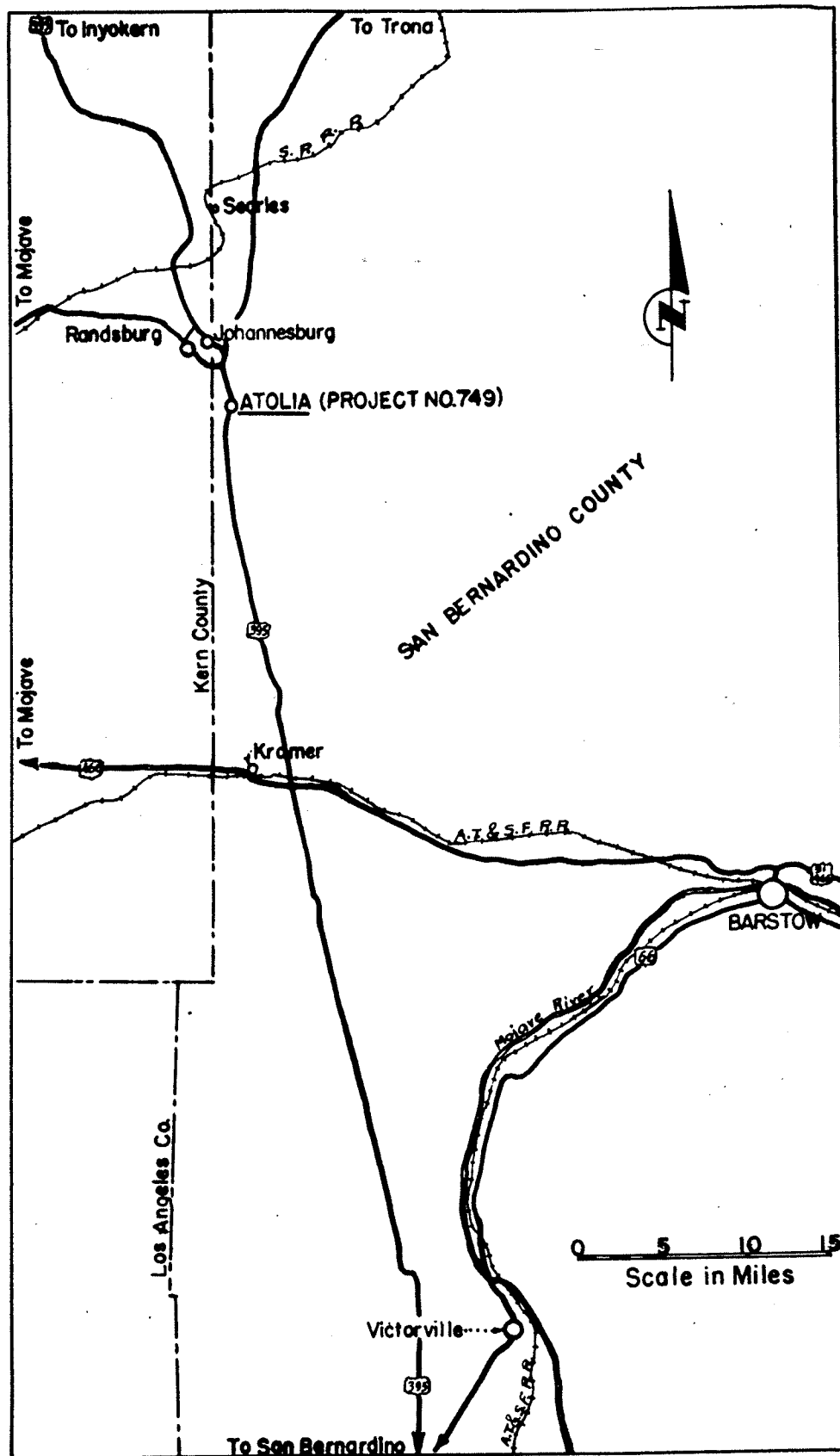


Figure 1. - Index map.

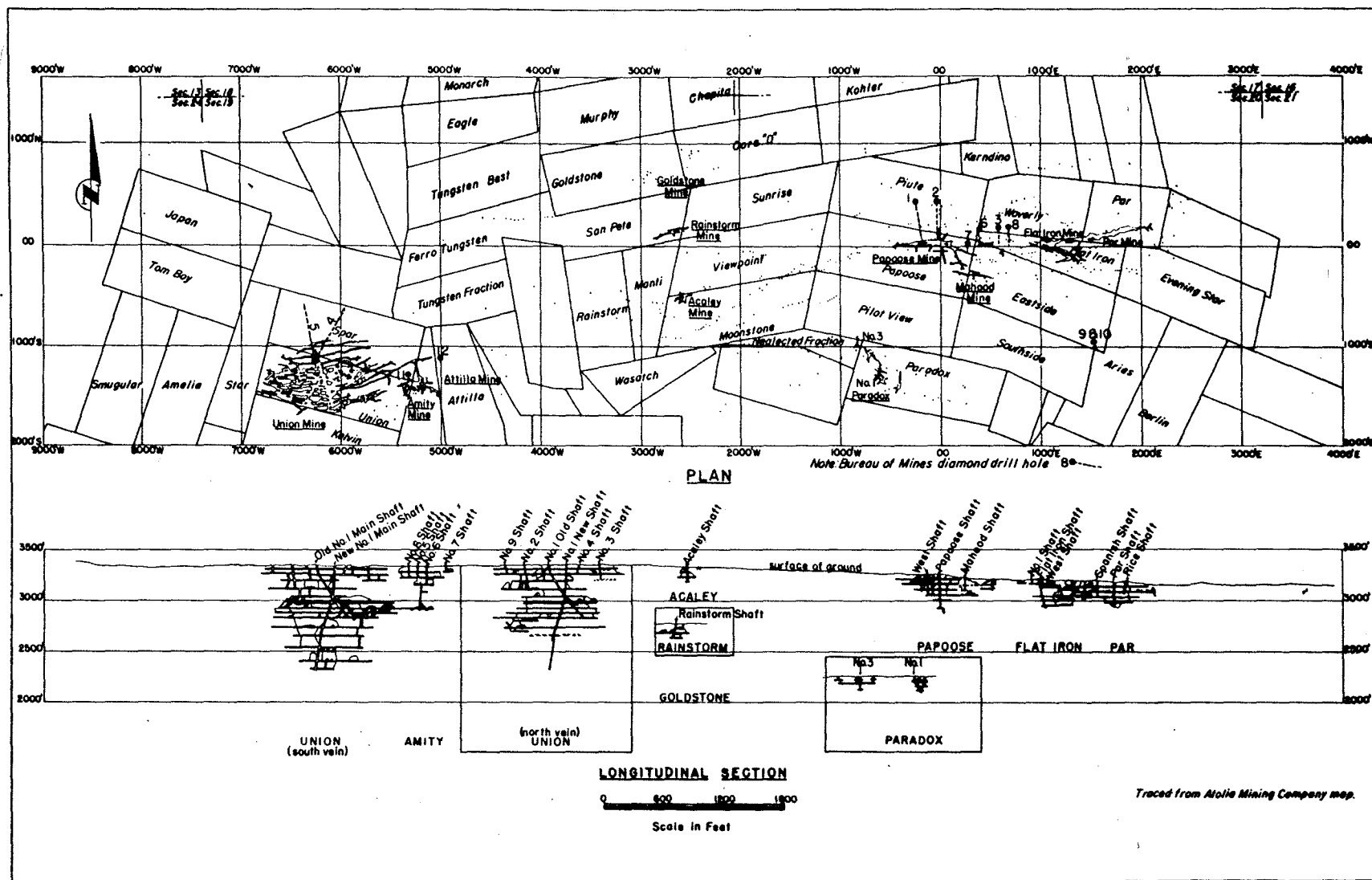


Figure 2. - Atolia mines, San Bernardino County, Calif.

The deposits are shallow, with the exception of those of the Union mine, where ore has been mined to a vertical depth of more than 850 feet. The majority of the ore shoots, however, terminated at depths less than 200 feet.

There are over 60,000 feet of underground workings in the district; 70 percent are in the Amity, Flat Iron, Papoose, Par and Spanish, Paradox No. 3, Union, and Redondo Pete mines. More than half of the total production is reported to have come from the Union mine.

WORK PERFORMED BY THE BUREAU OF MINES

Owing to labor shortage existing in California at the time of the project, diamond drilling was considered to be the most feasible and rapid method of exploration. Twelve diamond-drill holes were completed for a total of 5,056 feet. All of the drilling was in quartz monzonite, a great part of which was highly altered and crumbly, so that core recovery was only 61.3 percent.

Figures 1 and 2 show the district location, general plan and section of principal workings, and position of all drill holes.

The holes were distributed as follows (fig. 2):

Surface holes

- 2 Amity mine area (holes 11 and 12)
- 2 tailings pond area (holes 9 and 10)
- 6 papoose mine area (holes 1, 2, 3, 6, 7, and 8)

Underground holes

- 2 Union mine - 8th level (holes 4 and 5)

Several attempts were made to drill deep holes beneath the fault zone in the Papoose area. The fault zone was penetrated, but it was impossible to get through with the equipment available. Holes A-2 and A-3 reached depths of 523 and 580 feet, respectively, but were finally abandoned and the attitude of the fault zone was undetermined. These holes, however, intersected several small seams 1 to 2 inches thick, showing WO_3 content of from 0.72 to 12.87 percent.

The most promising results were obtained from holes A-11 and A-12. These were drilled in a virgin area north of Amity mine. There were 10 intersections of narrow veins up to 2.5 inches thick with a WO_3 content of 1 to 12 percent. Four stringers showing WO_3 content up to 9.49 percent also were intersected by hole A-7 in the Papoose area. Holes 9 and 10 were drilled under the "Old Spud Patch." Summary of assays is as follows:

Hole No.	Footage	Size	Core		Percent W ₀₃	
			Percent recovery		Core	Sludge
A-1.....	191.30 to 191.50	AX		92	12.87	
	494.00 to 503.00	AX		24	*0.01	*0.01
	503.00 to 505.00	AX		55	*0.01	*0.01
	505.00 to 508.00	AX		22	*0.01	*0.01
	508.00 to 514.00	AX		27	*0.01	*0.01
	514.00 to 519.00	AX		22	*0.01	*0.01
	519.00 to 530.00	AX		9	*0.01	*0.01
	530.00 to 535.00	AX		14	*0.01	*0.01
	535.00 to 541.00	AX		0	-	*0.01
	541.00 to 546.00	AX		10	*0.01	*0.01
	546.00 to 555.00	EX		11	*0.01	*0.01
	555.00 to 576.00	EX		29	*0.01	*0.01
	576.00 to 580.00	EX		0	-	*0.01
A-2.....	64.00 to 64.30	NX		100	0.72	
	518.00 to 518.70	AX		100	*0.01	
A-3.....	145.50 to 145.60	BX		100	1.07	
	374.50 to 375.00	EX		100	*0.01	
A-6.....	56.96 to 57.00	NX		100	0.81	
	373.50 to 373.70	EX		100	2.24	
A-7.....	151.80 to 153.00	EX		100	0.28	
	160.70 to 161.00	EX		100	9.49	
	227.00 to 227.20	EX		100	2.10	
	233.00 to 233.10	EX		100	2.63	
	256.00 to 256.55	EX		100	7.67	
A-8.....	114.50 to 115.30	EX		100	*0.01	
A-10.....	185.00 to 185.20	EX		100	*0.01	
A-11.....	244.50 to 244.65	AX		100	0.92	
	263.50 to 263.70	AX		100	*0.01	
	264.00 to 264.11	AX		100	0.08	
	265.50 to 265.65	AX		100	1.53	
	269.00 to 269.10	AX		100	3.26	
	298.00 to 298.25	AX		100	5.07	
	309.50 to 309.70	AX		100	0.17	
	313.00 to 313.15	AX		100	12.65	
	339.50 to 340.00	AX		100	0.42	
	358.00 to 358.10	AX		100	*0.01	
	362.50 to 362.72	AX		100	2.12	
	367.80 to 368.00	AX		100	11.43	
	368.50 to 368.60	AX		100	2.66	
A-12.....	320.00 to 320.10	EX		100	37.22	
	329.00 to 329.10	EX		100	1.80	
	396.00 to 396.10	AX		100	12.97	

*Less than.

DIAMOND-DRILLING DATA

One drill was operated two shifts per day and 6 days per week except when drilling the two holes underground, when two drills operated one shift per day 6 days per week. The total drill shifts was 328. The type of drilling was distributed as follows:

	Feet
Standpipe	250
"NX" hole	357
"EX" hole	2,281
"AX" hole	2,133
"EX" hole	35
	5,056

Detailed logs of holes are shown in appendix A.

APPENDIX A DIAMOND DRILL-HOLE LOGS

Hole 1

Coordinates: 450 N., 255 W.
Elevation: 3,281 feet

Bearing: S. 9° 30' E.
Dip: -45°
Depth: 580 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 25	0	Decomposed quartz monzonite.
25 to 166'5"	51	Mostly massive quartz monzonite cut by numerous joints and fractures. Local areas contain much calcite, kaolin, chlorite, and limonite. Thin seams of calcite along joints.
166'5" to 167	100	Clay gouge and crushed quartz monzonite.
167 to 169'3"	100	Jointed quartz monzonite with a 2-foot area containing much chloritized biotite and hornblende.
169'3" to 175'10"	100	Jointed and slightly kaolinized quartzite monzonite.
175'10" to 177	100	Highly chloritized quartz monzonite.
177 to 181'9"	89	Broken, kaolinized, sheared, and jointed quartz monzonite.
181'9" to 189'6"	90	Highly chloritized area.
189'6" to 191'4"	92	Massive jointed quartz monzonite.
191'4" to 191'6"	92	Quartz-scheelite vein which assayed 12.87 percent WO ₃ .
191'6" to 241	93	Jointed quartz monzonite with thin seams of calcite along joints. Local areas contain much kaolin and chlorite.

Hole 1 (Cont'd.)

Depth, ft.	Percent core recovery	Description
241 to 242	86	Chloritized quartz monzonite that is badly broken and jointed.
242 to 245	83	Broken and jointed quartz monzonite.
245 to 246	100	Chloritized quartz monzonite. Highly jointed with greenish calcite and kaolin on joint surfaces.
246 to 259	78	Jointed massive quartz monzonite.
259 to 265	90	Chloritized quartz monzonite.
265 to 309	66	Zone made up of jointed, altered, and broken quartz monzonite. Considerable pyrite from 279 to 280 feet. Calcite and kaolin very common.
309 to 319	30	Fault zone. Core in zone badly crushed, sheared, and kaolinized.
319 to 338'5"	73	Jointed, broken, and slightly altered quartz monzonite.
338'5" to 344	48	Pilot View fault (?) Contains sheared, broken, and altered quartz monzonite.
344 to 418	79	Jointed, broken, and altered quartz monzonite. Feldspar locally converted to kaolin and calcite. An occasional crystal of pyrite on joint surface. Also some greenish kaolin on joint surfaces.
418 to 428	32	Fault zone. The quartz monzonite is badly broken, sheared, and altered.
428 to 470	38	Core recovery in this interval very poor. Highly jointed, altered, and sheared quartz monzonite.
470 to 480	17	Big Gouge fault zone (?) Zone including fault is highly altered and contains much sheared and kaolinized material.
480 to 494	21	Broken, jointed, and crushed quartz monzonite.
494 to 503	24	Broken, jointed, kaolinized, and sheared quartz monzonite. Finely disseminated scheelite in sheared and altered part of core. (1.10 to 0.12 percent WO_3 ?)
503 to 505	55	Comparatively fresh quartz monzonite; few crystals of scheelite visible.
505 to 508	22	Broken and jointed quartz monzonite. A few crystals of disseminated scheelite visible. (about 0.10 percent WO_3 ?)
508 to 514	27	Broken and jointed quartz monzonite that contains a few crystals of scheelite. (0.10 percent ?)
514 to 519	22	Broken and jointed quartz monzonite containing local areas of kaolinized feldspar and chloritized biotite. Few crystals of scheelite visible.

Hole 1 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
519 to 530	9	Broken, jointed, and slightly kaolinized quartz monzonite containing a few disseminated crystals of scheelite. Scheelite has yellowish fluorescent color.
530 to 535	14	Partly decomposed quartz monzonite. About 0.10 to 0.14 percent WO_3 .
535 to 541	0	No core.
541 to 546	10	Comparatively fresh quartz monzonite. About 0.06 to 0.10 percent WO_3 .
546 to 555	11	Very poor core recovery. Core is unaltered quartz monzonite. About 0.04 percent WO_3 .
555 to 576	29	Very poor core recovery. Core is unaltered quartz monzonite. About 0.04 percent WO_3 .
576 to 580	0	No core recovery. Attempts to cement hole proved futile. Unable to cut off running sand between 545 and 580 feet. Hole abandoned.

Hole 2

Coordinates: 450 N., 30 W.
Elevation: 3,275 feet

Bearing: South
Dip: -50°
Depth: 530 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 65	27	Very poor core recovery. Rock is decomposed, altered, sheared, jointed, and broken quartz monzonite. Local areas more altered and sheared than others. Considerable limonite, calcite, and kaolin in several places. Drusy coatings of calcite are common. One inch of chalcedonia quartz at 64 feet that contains some scheelite. Much limonite and calcite with scheelite.
65 to 195	68	Broken, jointed, sheared, and altered quartz monzonite. Many areas altered to kaolin and chlorite with much limonite and calcite. Calcite is usually brown in color and is found as veinlets along joints and in broken areas. An occasional small area contains some sericite. Sphene very common in those areas containing much chlorite.

Hole 2 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
195 to 241	75	Broken, jointed, and altered quartz monzonite. Considerable sphene in those highly chloritized areas. Some calcite and kaolin in altered areas along joints. Small fault passes through at 240.5 feet with 3 inches of gouge.
241 to 265	25	Very poor core recovery in this interval. Rock badly sheared and broken at 242 feet - small fault with several inches of gouge. Planty of limonite stained calcite and kaolin.
265 to 418	73	Much of this interval consists of relatively fresh quartz monzonite. Local areas badly altered. The secondary minerals are calcite, kaolin, limonite, and chlorite. Some sphene in chloritized areas.
418 to 456	62	Pilot view fault zone, shear zone. Feldspar and ferromagnesian minerals have been altered to kaolin and chlorite. The quartz has been crushed and stained a roddish-brown color by limonite. Good core recovery in sheared quartz monzonite.
456 to 530 :	50	Broken, jointed, and slightly altered quartz monzonite. Little shearing at 472 feet. Unaltered quartz monzonite contains large biotite crystals. One inch of quartz with some scheelite in an 8-inch shear zone at 513 feet. Also, few small areas of limonite and some calcite.

Hole 3

Coordinates: 186 N., 590 E.
Elevation: 3,228 feet

Bearing: South
Dip: -65-1/2°
Depth: 378 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 52	0	No core recovery. Rock is decomposed and altered quartz monzonite.
52 to 86	11	Decomposed, sheared, jointed, and altered quartz monzonite. Calcite and kaolin are chief secondary minerals. Considerable chlorite from 79 to 83 feet. Chlorite in places gives rock a streaky appearance.

Hole 3 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
86 to 120	88	Jointed, alightly broken, and slightly altered quartz monzonite. Alteration is essentially along joints and in broken areas. Kaolin, calcite, and some limonite are secondary minerals. 1-1/2 inch seam of calcite at 110 feet. Rock on the whole, is reasonably fresh and unaltered.
120 to 159	99	Broken, jointed, slightly sheared and altered quartz monzonite. Small fault at 155 feet with 2 inches of gouge and 5 inches of sheared and broken rock. Several 1/2-inch seams of calcite along joints and in broken and altered areas. Chlorite gives rock a streaky appearance in a number of places.
159 to 211.5	91	Jointed, slightly broken, and sheared quartz monzonite. Some calcite and kaolin in rock. Small fault at 194 feet with 4 inches of broken and gougy material. From 194 feet to 198 feet rock is badly sheared and cut by many flat-lying joints. Alteration intense in sheared areas with considerably calcite and kaolin present. Some chlorite at 204 feet. Reddish material coating kaolin on joints. Color probably due to some oxide of iron.
211.5 to 235.5	92	Broken, jointed, and slightly sheared quartz monzonite. Many flat-lying kaolin coated joints and shears. Considerable shearing and chlorite from 225 to 230 feet.
235.5 to 294.5	97	Jointed, broken and slightly altered quartz monzonite. Some calcite and kaolin in altered areas and along the joints. Small fault at 259 feet with 2 inches of gouge material.
294.5 to 330	87	Broken, jointed, and slightly altered quartz monzonite. Much chlorite at 302.5 feet. Little pyrite in sheared areas. Also, some quartz and considerable chlorite in sheared areas.

Hole 3 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
330 to 346	91	Sheared, altered, jointed, and broken quartz monzonite. From 330 to 331 feet the rock is highly chloritized. At 336 feet there is a highly sheared area with the material being a dark greasy grey color. From 337 to 339 feet there is another shear zone that contains some gouge and broken quartz. Most of the quartz in this zone carries some scheelite. Some pyrite in sheared rock. Rock from 339 to 344 feet slightly sheared.
346 to 378	73	Sheared, broken, altered, and jointed quartz monzonite. Intense shearing starts at 348 feet and continues through 361 feet. Considerable kaolin and calcite in sheared rock. Considerable chlorite at 375 feet. At 376 feet there is a 6-inch piece of core that shows some scheelite.

Hole 4

Coordinates: 1145 S., 6239 W.
Elevation: 2869 feet

Bearing: N. 30° E.
Dip: +20°
Depth: 644 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 17	93	Jointed, slightly broken, and relatively fresh quartz monzonite. Minor amounts of kaolin and calcite on joints and in areas of broken rock. Local area containing much needle hornblende at 12 feet.
17 to 30	78	Jointed, broken, and slightly altered quartz monzonite. Some calcite and kaolin on joints. Small amount of sericite visible in broken and jointed regions.
30 to 48	61	Jointed, broken, and slightly altered quartz monzonite. Considerable chlorite at 46 and 48 feet.
48 to 56	40	Altered, sheared, jointed, and broken quartz monzonite. Some intense shearing and bleaching from 48 to 51 feet. Small fault zone.

Hole 4 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
56 to 70	46	Jointed, broken, and slightly altered quartz monzonite. Kaolin is chief secondary mineral.
70 to 170	77	Jointed, massive, and very slightly altered quartz monzonite. Few seams of brown calcite are common. Also local areas of kaolin. A 5-inch gouge zone at 80 feet. Small fault. An occasional patch of limonite.
170 to 175	70	Massive, jointed, and unaltered quartz monzonite. From 173 to 175 feet is a zone composed of gouge and claylike material heavily stained with limonite.
175 to 255	79	Jointed, broken, and altered quartz monzonite. An occasional area as much as 2 feet in length highly oxidized. Few seams of brown calcite and cream-colored kaolin. Several areas contain considerable needle hornblende.
255 to 370	85	Jointed, broken, and slightly altered quartz monzonite. Local areas contain much needle hornblende. Alteration is essentially along joints and in broken areas. From 354 to 360 feet is a zone composed of darker quartz monzonite. In this zone the ferromagnesian mineral is chiefly biotite which makes up approximately 60 percent of the rock. Few narrow seams of brown calcite. At 359.5 feet is a streaky zone that includes much epidote and chlorite.
370 to 380	54	Broken, jointed, and altered quartz monzonite. From 373 to 375 feet is a zone of quartz monzonite that exhibits scheelite structure. Also, some epidote and chlorite from 374 to 380 ft. a 1 inch seam of gouge at 373.5 feet. Kaolin and calcite are other secondary minerals. Small fault.
380 to 444	45	Broken, altered, and jointed quartz monzonite. Several streaks of epidote and quartz. Also much calcite and kaolin along joints and in broken areas. Drusy coatings of quartz on joint surfaces.
444 to 448	100	Broken, jointed, and slightly altered quartz monzonite. Small fault at 448 feet. One inch of gouge.

Hole 4 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
448 to 550	76	Jointed, broken, and very slightly altered quartz monzonite. Several narrow zones of epidote and quartz. An occasional area contains a red material resembling cinnabar. No cinnabar in this section of core.
550 to 644	73	Jointed, broken, and slightly altered quartz monzonite. Intensely oxidized and altered zone from 553 to 559 feet. Few calcite seams. Also, some pyrite in quartzose areas. Pyrite also found in altered areas with calcite and kaolin.

Hole 5

Coordinates: 1150 S., 6250 W.
Elevation: 2868 feet

Bearing: N. 10° W.
Dip: +17°
Depth: 604 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 35	67	Broken, jointed, and slightly sheared quartz monzonite. Few seams of white calcite along joints and in fractures.
35 to 100	83	Jointed massive quartz monzonite with a small fault at 99 feet. Material in fault is gouge and sandy quartz monzonite.
100 to 121.5	80	Broken, jointed, and massive quartz monzonite. Several narrow seams of white calcite. Broken and oxidized zone from 112.5 to 113.5 feet. Considerable sphene in altered parts of core.
121.5 to 170	95	Jointed massive quartz monzonite. Several narrow seams of calcite along joints. Small amount of kaolin with some limonite in the slightly sheared quartz monzonite.
170 to 229	79	Jointed, broken, and slightly altered quartz monzonite. Alteration essentially along joints and in broken areas. Kaolin, calcite, and minor amounts of limonite are secondary minerals. Several prominent joints with kaolin are found trending more or less parallel to the core. A small fault at 196.5 feet with 2 inches of gouge. The rock around the small fault is

Hole 5 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
		slightly sheared and has a streaky appearance. Streaky appearance due to narrow stringers of chlorite. Few small bands of brown calcite. The quartz monzonite on either side of small fault is fine-grained and contains less biotite than noted elsewhere.
229 to 283	77	Massive, jointed and broken quartz monzonite. Some kaolin along flat-lying joints.
283 to 287	8	Very poor core recovery in broken and jointed quartz monzonite. Sandy and gougy material indicates small fault.
287 to 360	70	Essentially massive, jointed, and very slightly altered quartz monzonite. Some calcite and kaolin in broken areas and along joints.
360 to 391	93	Massive, jointed, and slightly altered quartz monzonite. Numerous narrow bands of epidote and quartz. The zone from 381 to 382 feet contains many of these epidote and quartz bands. Few narrow seams of white calcite and quartz along joints. Many flat-lying joints in this area with kaolin on the joint.
391 to 413	74	Jointed, broken, and slightly altered quartz monzonite. Streaky 392 and 393.5 feet. Streaky appearance due to streaks of epidote, chlorite, and quartz. Several narrow bands of white and limonite-stained calcite along joints. 1-1/2 inch zone of gouge at 413 feet. Small fault. Alteration mainly along joints and in broken areas.
413 to 441	55	Jointed, broken, and slightly altered quartz monzonite. Intensely sheared and faulted area from 429 to 431 feet. Considerable leaching and bleaching in sheared area, several 1/4-inch seams of brown calcite. From 436 to 441 feet is a zone that contains much chlorite and epidote.
441 to 451	97	Jointed, broken, and altered quartz monzonite. The alteration is that of biotite and hornblende to chlorite. Thin streaks of chlorite give rock a net-like texture. From 445 to 446.5 feet is a zone made up of epidote and quartz. Numerous thin seams of calcite with some kaolin are common.

Hole 5 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
451 to 483	78	Broken, jointed, and sheared quartz monzonite. At 453 feet is a 1-1/2-inch seam of white calcite in sheared quartz monzonite. In the sheared zones are numerous narrow bands of epidote and quartz (mixture). At 461 feet is a 1-inch gouge seam. Small fault. Also, at this place the quartz monzonite is highly altered and bleached. There are numerous coatings of drusy calcite along joints and breaks. At 474 feet is a 3-inch band of a mixture of epidote and quartz.
483 to 524	96	Jointed, massive, and very slightly altered quartz monzonite. Several 1-inch bands of a mixture of epidote and quartz. From 498 to 506 feet is a zone containing calcite, kaolin, and chlorite.
524 to 564	98	Jointed massive quartz monzonite. Several small areas of kaolin and calcite at 555.5 feet. At this place there is a 3-inch band of quartz and epidote mixture.
564 to 594	97	Massive, jointed quartz monzonite. Few local areas of kaolin and some calcite.
594 to 604	100	Massive, jointed quartz monzonite.

Hole 6

Coordinates: 165 N., 400 E.
Elevation: 3,238 feet

Bearing: South
Dip: -65°
Depth: 397 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 45	0	No core recovered, rock is decomposed quartz monzonite.
45 to 106	46	Jointed, altered, and slightly sheared quartz monzonite. Rock sheared from 47 to 62 feet with some alteration. The secondary minerals are calcite, kaolin, and chlorite. Considerable chlorite from 104 to 105 feet. Little quartz around 59 feet.

Hole 6 (Cont'd.)

<u>Depth ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
106 to 169	46	Jointed and slightly sheared quartz monzonite. Numerous joint surfaces contain thin coatings of calcite and kaolin. At 119 feet there is some very light colored quartz monzonite that contains very little biotite and an abundance of quartz grains. A 1/8-inch calcite seam along several flat-lying joints. The light-colored quartz monzonite starts at 146 feet and ends at 158 feet. 1/2-inch seam of calcite at 141 feet.
169 to 188	94	Jointed, slightly sheared, and massive quartz monzonite. Little epidote in rock at 187 feet. At various places the quartz has pale pink tinge.
188 to 251	80	Jointed massive quartz monzonite with local areas altered to kaolin and calcite. Calcite and kaolin are found essentially along joints and in broken areas. There are several flat-lying joints from 189 to 192 feet. Some chlorite at 231 feet. Several joint surfaces around 225 feet have reddish material on them.
251 to 292	75	Jointed massive quartz monzonite. Some chlorite at 261 feet. Considerable sphene in chloritized areas. Calcite and kaolin occur in jointed areas.
292 to 321	81	Jointed, massive, and slightly altered and sheared quartz monzonite.
321 to 335	74	Sheared, jointed, altered quartz monzonite. Intense shearing from 326 to 328 feet with some pyrite in sheared rock. All feldspar and biotite have been altered and the quartz slightly crushed. A dull red stain is common along joint surfaces in the sheared rock. Rock also sheared from 334 to 335 feet.
335 to 355	100	Jointed, broken, and slightly sheared quartz monzonite. Rock sheared at 335 feet and from 338 to 339 feet; also at 353 feet to 354 feet. Dull red stain is common along joints in sheared rock. Some chlorite in sheared areas. Rock in unaltered and unshoared areas is rather contorted and has a gneissose structure.

Hole 6 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
355 to 365	100.	Jointed, slightly sheared, and slightly altered quartz monzonite. Few calcite veinlets at 355 feet. Shearing starts at 360 feet and ends at 363 feet. Some kaolin, calcite, and chlorite in sheared rock.
365 to 397	84	Jointed, sheared, and faulted quartz monzonite. The rock is massive up to 367 feet. From 367 to 375 feet the rock is only slightly sheared in which much of the feldspar and biotite are unaltered. A 1-1/2-inch of quartz at 373 feet in sheared rock. Rock from 372 to 397 foot becomes progressively more sheared and bleached. From 375 to 386 feet the rock is cut by many joints that have dull reddish material on their surfaces. In this interval most of the biotite has been altered along with much of the feldspar. From 389 to 397 feet the rock is intensely sheared and gougy. Considerable gouge present and a remarkably good core recovery. Nearly all of the feldspar has been altered to kaolin and calcite, and all ferromagnesian minerals to light colored minerals. Pilot view fault zone starts at 375.5 feet and continues beyond end of hole.

Hole 7

Coordinates: 28 N., 272 E.
Elevation: 3243 feet

Bearing: South
Dip: -70°
Depth: 291 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 99	12	Decomposed and jointed quartz monzonite. Considerable chlorite from 40 to 55 feet. Few narrow veinlets of quartz from 0 to 28 feet. Calcite and kaolin are present. Very poor core recovery throughout this interval.
99 to 152	33	Jointed and slightly altered quartz monzonite. Considerable chlorite at 99, 109, and from 146.5 to 152 feet. Calcite and kaolin are present. A 2-inch vein of quartz at 152 feet that shows a little schoelite.

Hole 7 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
152 to 175.5	42	Jointed, slightly sheared, and altered quartz monzonite. Scheelite present in some quartz from 160.7 to 161.3 feet. The scheelite in this quartz has been partly dissolved out, leaving voids and casts in the quartz. Considerable chlorite at 158 and 168 feet. Scheelite from 152 to 153 feet.
175.5 to 219	65	Jointed and slightly altered quartz monzonite. Calcite and kaolin are common in jointed and broken areas. Rock from 201 to 219 feet very massive and not altered.
219 to 233	89	Jointed and very slightly altered quartz monzonite. Joint surfaces contain limonite stained calcite and kaolin. Limonite derived from oxidized pyrite. A 2-inch quartz vein at 227 feet which shows some scheelite. Quartz shows vuggy character due to solution of scheelite.
233 to 246	81	Jointed and massive quartz monzonite. The rock from 240 to 234 feet has gneissose appearance. Some quartz at 233 feet that has some scheelite.
246 to 270	69	Jointed, sheared, and altered quartz monzonite. Some chlorite at 249 feet. Two inches of gouge at 249.5 feet. Rock on each side of gouge is highly sheared and the zone from 248 to 252 feet is the pilot view fault zone. 2 inches of quartz at 256.5 feet that shows a little scheelite. Rock from 257 to 268 feet has been highly chloritized and slightly sheared. Few narrow quartz veins with some calcite but no scheelite at 263.5 and 265 feet.
270 to 291	65	Jointed, slightly sheared, and slightly altered quartz monzonite. Some chlorite at 283 feet.

Hole 8

Coordinates: 192 N., 700 E.
Elevation: 3225 feet

Bearing: South
Dip: -65-1/2°
Depth: 383 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 106	14	Very poor core recovery in broken, and slightly altered quartz monzonite. Several 1/4-inch veins of quartz in interval from 90 to 106 feet.
106 to 155	79	Jointed, broken, and slightly altered quartz monzonite. Considerable chlorite from 117 to 121 feet. Several 1/4-inch calcite seams from 133 to 138 feet along flat-lying joints. Several flat-lying joints from 138 to 141 feet. At 154.5 feet is a broken and oxidized zone, considerable limonite present.
155 to 170.5	85	Sheared, jointed, and altered quartz monzonite. Much quartz from 155 to 156 feet. From 156 to 168 feet the rock is badly sheared and altered. Fairly good size fault zone from 167.5 feet to 169.5 feet with much gouge and sheared material. Some quartz at 169.5 feet, (about 5 inches of broken quartz).
170.5 to 218	91	Jointed and slightly altered quartz monzonite. Much of the rock is massive and unaltered. At 197.5 feet there is a 6-inch streak composed essentially of biotite with little quartz. Several local areas of calcite and kaolin. Some chlorite in streaks at 209 feet.
218 to 256	91	Jointed, slightly gneissic, and massive quartz monzonite. At 227 feet and 242 feet the rock has gneissic appearance. Some chlorite from 239 to 242 feet. Local areas include some kaolin and calcite.
256 to 297	69	Jointed, slightly sheared, and altered quartz monzonite. Several flat-lying joints that contain calcite and kaolin. Shear zone from 279.5 to 281 feet that contains some quartz in 1/2-inch flat-lying veins. Some sericite and kaolin with a small amount of chlorite. A 3/4-inch calcite vein in sheared rock. There is a purplish material that coats joint surfaces. Probably an oxide of iron.

Hole 8 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
297 to 353	59	Jointed, faulted, and slightly altered quartz monzonite. Possibly a fault from 330 to 336 feet. Very poor core recovery in this interval as well as from 339 to 347 feet. Another zone in which there was poor core recovery is from 349 to 353 feet. Much calcite and kaolin scattered throughout rock and some concentrated along joints and in broken areas. One inch of calcite at 315.5 feet in sheared rock. Some scheelite-bearing quartz at 339 feet.
353 to 383	15	Faulted, jointed, and slightly altered quartz monzonite. Faults in intervals from 361 to 366 feet, 366 to 372 feet and 372 to 383 feet. Small amount of pyrite in sheared rock from 366 to 383 feet. Very poor core recovery in these above listed zones.

Hole 9

Coordinates: 947 S., 1530 E.
Elevation: 3,154 feet

Bearing: S. 25° E.
Dip: -45°
Depth: 180 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 61	3	Very poor core recovery in decomposed quartz monzonite. A 1/2-inch calcite vein at 61 feet with considerable limonite and kaolin.
61 to 115	9	Very poor core recovery in sheared decomposed, and altered quartz monzonite. Most of the feldspar has been altered to kaolin and the biotite to chlorite. A 1/2-inch vein of calcite at 115 feet.
115 to 180	11	Decomposed and sheared quartz monzonite. Rock badly sheared from 116 to 170 feet with a small amount of gouge at 168 to 170 feet. First unaltered rock encountered at 179 feet. Small fault passes through from 168 to 170 feet.

Hole 10

Coordinates: 947 S., 1530 E.
Elevation: 3154 feet

Bearing: S. 25° E.
Dip: -67°
Depth: 260 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 32	2	Very poor core recovery in decomposed quartz monzonite. Decomposed rock contains considerable kaolin and calcite.
32 to 125	35	Decomposed, altered, and jointed quartz monzonite. Few calcite veins at 53 feet that contain a small amount of scheelite. Fractures in rock are filled with drusy quartz. Kaolin and chlorite are common throughout this section of core. A fault passes through at 101.5 feet with 3 inches of gougy and broken material. Local areas contain some epidote.
125 to 146.5	55	Decomposed, jointed, and slightly altered quartz monzonite. Much of the feldspar has been converted to kaolin as well as much of the biotite to chlorite. Small amount of sheared rock at 136 feet.
146.5 to 215	33	Jointed, sheared, and altered quartz monzonite. Considerable amount of the rock from 146 to 196 feet is sheared and a small fault passes through somewhere between 165 to 177 feet where the rock is intensely sheared and gougy. Some epidote at 162 feet. Two inches of quartz at 185 feet and 1-1/2 inches of quartz at 196 feet.
215 to 260	65	Jointed, sheared, and altered quartz monzonite. Numerous flat-lying joints from 225 to 250 feet. Limonite stained kaolin and calcite very common along joint surfaces.

Hole 11

Coordinates: 1275 S., 5325 W.
Elevation: 3321 feet

Bearing: South
Dip: -80°
Depth: 397 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 23	0	No core recovery. Standpipe.
23 to 150	63	Massive quartz monzonite that is slightly jointed, broken, and altered. The alteration is mainly along joints and in broken areas. Small fault from 140 to 140.5 feet with gougy and sandy material. A 1-inch seam of limonite at 142 feet.
150 to 177	94	Massive quartz monzonite. From 162 to 162.5 feet there is a small amount of pink calcite in some altered rock.
177 to 231	67	Jointed and altered quartz monzonite. Badly broken from 182 to 183.5 feet. Small fault from 183.5 to 184 feet with gougy material and several calcite veinlets. From 192.5 to 193.5 feet rock is altered. At 210 feet there is a 2-inch vein of white quartz that contains no scheelite.
231 to 282	87	Jointed, broken and slightly altered quartz monzonite. Rock badly broken from 250 to 254 feet. A 1-inch vein of white calcite at 237 feet. From 244.5 to 244.65 feet is a white quartz vein that contains scheelite. From 263.5 to 263.7 feet is a quartz calcite vein that has scheelite; 264.11 is a quartz vein with some scheelite; 265.5 to 265.65 is another quartz vein with some scheelite; and from 269 to 269.1 is a quartz vein with some scheelite. From 269 to 270 feet the rock is highly altered and there is considerable limonite. From 271 to 271.8 feet there is a fault with 4 inches of gouge and several inches of sheared rock. At 272 feet there are two very narrow veins of white quartz that carry no scheelite.
282 to 305	53	Jointed and broken quartz monzonite. At 298 to 298.25 feet there is a white quartz vein with some scheelite.

Hole 11 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
305 to 330	58	Badly broken and jointed quartz monzonite. From 309.5 to 309.7 foot is a quartz vein with some scheelite. Also, from 313 to 313.15 foot is a quartz vein with some scheelite.
330 to 397	61	Jointed, broken, and slightly sheared and altered quartz monzonite. At 339.5 foot there is a quartz vein which is at least 4 inches in width that carries considerable scheelite. From 358 to 358.1 foot is a quartz vein with some scheelite; from 362.5 to 362.72 is a quartz vein with some scheelite; from 367.8 to 368 foot is a quartz vein with some scheelite; from 368.5 to 368.6 foot is a quartz vein with some scheelite, and it seems that the interval from 358 to 368.6 feet is made up of quartz veins in a slightly altered and oxidized quartz monzonite. From 380.5 to 381 foot there is a small fault with 4 inches of gouge.

Hole 12

Coordinates: 1108 S., 5005 W.
Elevation: 3,336 feet

Bearing: South
Dip: -83°
Depth: 412 feet

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
0 to 30	0	No core recovery. Standpipe 3-1/2 inches to 26 feet.
30 to 49	77	Slightly altered and jointed quartz monzonite. Kaolin and calcite are the main secondary minerals.
49 to 168	82	Jointed massive quartz monzonite. One-inch seam of white calcite at 60 feet.
168 to 199	65	Poor core recovery in broken, altered, jointed, and slightly sheared quartz monzonite. Many flat-lying joints in this interval, which contained calcite and kaolin.
199 to 208	26	Jointed massive quartz monzonite, with a few local altered areas.
208 to 271.5	93	Jointed massive quartz monzonite. Some altered rock in highly jointed areas.

Hole 11 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
305 to 330	58	Badly broken and jointed quartz monzonite. From 309.5 to 309.7 feet is a quartz vein with some scheelite. Also, from 313 to 313.15 feet is a quartz vein with some scheelite.
330 to 397	61	Jointed, broken, and slightly sheared and altered quartz monzonite. At 339.5 feet there is a quartz vein which is at least 4 inches in width that carries considerable scheelite. From 358 to 358.1 feet is a quartz vein with some scheelite; from 362.5 to 362.72 is a quartz vein with some scheelite; from 367.8 to 368 feet is a quartz vein with some scheelite; from 368.5 to 368.6 feet is a quartz vein with some scheelite, and it seems that the interval from 358 to 368.6 feet is made up of quartz veins in a slightly altered and oxidized quartz monzonite. From 380.5 to 381 feet there is a small fault with 4 inches of gouge.

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0 to 30	0	No core recovery. Standpipe 3-1/2 inches to 26 feet.
30 to 49	77	Slightly altered and jointed quartz monzonite. Kaolin and calcite are the main secondary minerals.
49 to 168	82	Jointed massive quartz monzonite. One-inch seam of white calcite at 60 feet.
168 to 199	65	Poor core recovery in broken, altered, jointed, and slightly sheared quartz monzonite. Many flat-lying joints in this interval, which contained calcite and kaolin.
199 to 208	26	Jointed massive quartz monzonite, with a few local altered areas.
208 to 271.5	93	Jointed massive quartz monzonite. Some altered rock in highly jointed areas.

Hole 12 (Cont'd.)

<u>Depth, ft.</u>	<u>Percent core recovery</u>	<u>Description</u>
271.5 to 306.5	78	Jointed, massive, slightly sheared and altered quartz monzonite. Intense kaolinization from 275 to 277 feet. Rock from 290 to 300 feet is bleached and altered. All feldspar has been converted to kaolin and calcite.
306.5 to 352.5	54	Jointed, sheared, and faulted quartz monzonite. Small fault passes through from 312 to 312.5 feet. From 312 to 320 feet the rock is altered and sheared with intense shearing from 313 to 315.5 feet. Barren quartz vein at 315 feet. The quartz vein from 320 to 320.1 feet has some scheelite; the quartz vein from 329 to 329.1 feet contains much coarsely crystalline scheelite, while the quartz vein at 324 feet is barren.
352.5 to 412	60	Jointed, massive, and very slightly altered quartz monzonite. Small fault passes through from 371 to 371.5 feet. From 393.5 to 396 feet the rock is altered and at 394 feet there is a 2-1/2-inch barren quartz vein. From 396 to 396.1 feet there is a quartz vein that carried scheelite. Considerable limonite around 295 feet. There is some gougy and sandy material at 412 feet. The drill probably started to enter the zone of the mid fault.